PROC. BIOL. SOC. WASH.
95(1), 1982, pp. 99–113

PHYTOPLANKTON DISTRIBUTION ALONG THE EASTERN COAST OF THE USA IV. SHELF WATERS BETWEEN CAPE LOOKOUT, NORTH CAROLINA, AND CAPE CANAVERAL, FLORIDA

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Abstract.—The phytoplankton composition is discussed for southeastern shelf waters of the United States with the average concentrations at near and far shore stations given for 328 species. A mixed ultraplankton group, composed of unidentified species, predominated in numbers, and was part of the shelf assemblage of dominant forms with diatoms, dinophyceans, and haptophyceans. Largest cell concentrations were noted near shore with the diatoms and the ultraplankton component most abundant. Phytoplankton assemblages are given for near and far shore stations over the shelf.

Phytoplankton composition in the continental shelf waters off the southeastern coast of the United States has been discussed by Hulburt (1967), Marshall (1969, 1971), and Hulburt and MacKenzie (1971). These studies have indicated diatoms abundant in the shelf populations with the coccolithophorids and other phytoflagellates becoming proportionally more significant beyond the shelf break and in the Gulf Stream. In addition to diatoms, dinophyceans, and coccolithophores, representatives from a few other phytoplankton groups have been found common in these waters. Hulburt and MacKenzie (1971) noted large concentrations of the cryptophycean *Rhodomonas amphioxeia* south and north of Cape Hatteras. Dunstan and Hosford (1977) reported an abundance of the cyanophyceans *Oscillatoria thiebautii* and *Oscillatoria erythraea* in the south Atlantic bight, with Marshall (1981) noting 16 cyanophycean species in these shelf waters. Bishop *et al.* (1980) indicated little seasonal change in nutrient or phytoplankton concentrations in this area. They emphasized more variability occurred on the outer shelf which may be related to intrusions of the Gulf Stream and upwelling along the shelf break. They also suggested a short-term response time of days to weeks by the phytoplankton to these events and that responses may differ throughout the year, resulting in changes in the concentrations among the various populations.

These past studies suggest this section of the continental shelf contains a diverse phytoplankton flora with regional variations and changes in population concentrations common. The purpose of this study was to evaluate the phytoplankton composition in this area of approximately 600 km along the shelf between Cape Lookout, N.C. and Cape Canaveral, Florida. Emphasis was placed on characterizing the populations from near and far shore stations over this section of the continental shelf.

Methods

Surface water samples were taken from 24 October to 16 November 1973 and 6–20 September 1978 during MARMAP cruises of the South Carolina Marine

Resources Program. These collections were generally taken along transects directed from the coastal area seaward to the vicinity of the shelf break, between Cape Lookout, N.C. and Cape Canaveral, Florida (Fig. 1). There were 43 stations in the 1973 collections and 48 stations in 1978. Station depths ranged from 9 m to 318 m, with 45 of the 91 stations located at water depths of less than 44 m. There were four stations in waters between 200 and 318 m deep. Reference to near shore stations are those located within 35 km from the nearest coastline, with those beyond this distance referred to as far shore stations. In this study 35 of the 91 stations were classified as near shore stations.

At each station a 500 ml surface sample was obtained with a Van Dorn collection bottle using standard hydrocast procedures. The samples were preserved immediately with buffered formalin and returned to the laboratory for subsequent settling. A modified Utermöhl method was used with the samples siphoned to a 20 ml concentrate, transferred to a settling chamber and examined with a Zeiss inverted plankton microscope. The classification format of Hendey (1974), Parke and Dixon (1976), Drouet and Daily (1956), and Drouet (1968) is mainly followed in this study. Salinity values and other station data were provided by personnel from the South Carolina Marine Resources Program.

Results

There were differences in the range and average values for temperature and salinity for the two cruises (Table 1). The 1973 collections came from water that was cooler and slightly less saline, with a broader temperature range represented than what was present in the 1978 samples. The combined average temperature for both of these cruises was 26.42°C, which was higher than the average fall temparature (22.4°C) during the previous collections in this area by Marshall (1971).

A total of 328 phytoplankters was identified in this study from the two cruises (Table 2). These consisted of Bacillariophyceae (194), Dinophyceae (83), Haptophyceae (13), Cyanophyceae (16), Euglenophyceae (7), Prasinophyceae (4), Chlorophyceae (3), Chrysophyceae (5), and Cryptophyceae (3). In addition, there were high concentrations of an unidentified ultraplankton component that was divided into three size categories, <3 μm, 3–5 μm, 5–10 μm. These consisted of round, oval, and irregularly shaped cells, with apparent light green color. Most numerous was the <3 μm size class which appeared similar to coccoid cyanophyceans, whereas the 3–5 μm category resembled chlorophyceans with the 5–10

Table 1.—Temperature and salinity values for surface water at stations during the fall 1973 and 1978 cruises.

	Temperature °C		Salinity ‰	
	1973	1978	1973	1978
Range	14.9–27.8	27.2–28.6	34.22–37.07	34.87–38.81
Mean	24.1	27.8	35.91	36.04
Near Shore Mean	23.2	27.8	35.69	35.84
Far Shore Mean	26.1	27.8	36.03	36.10

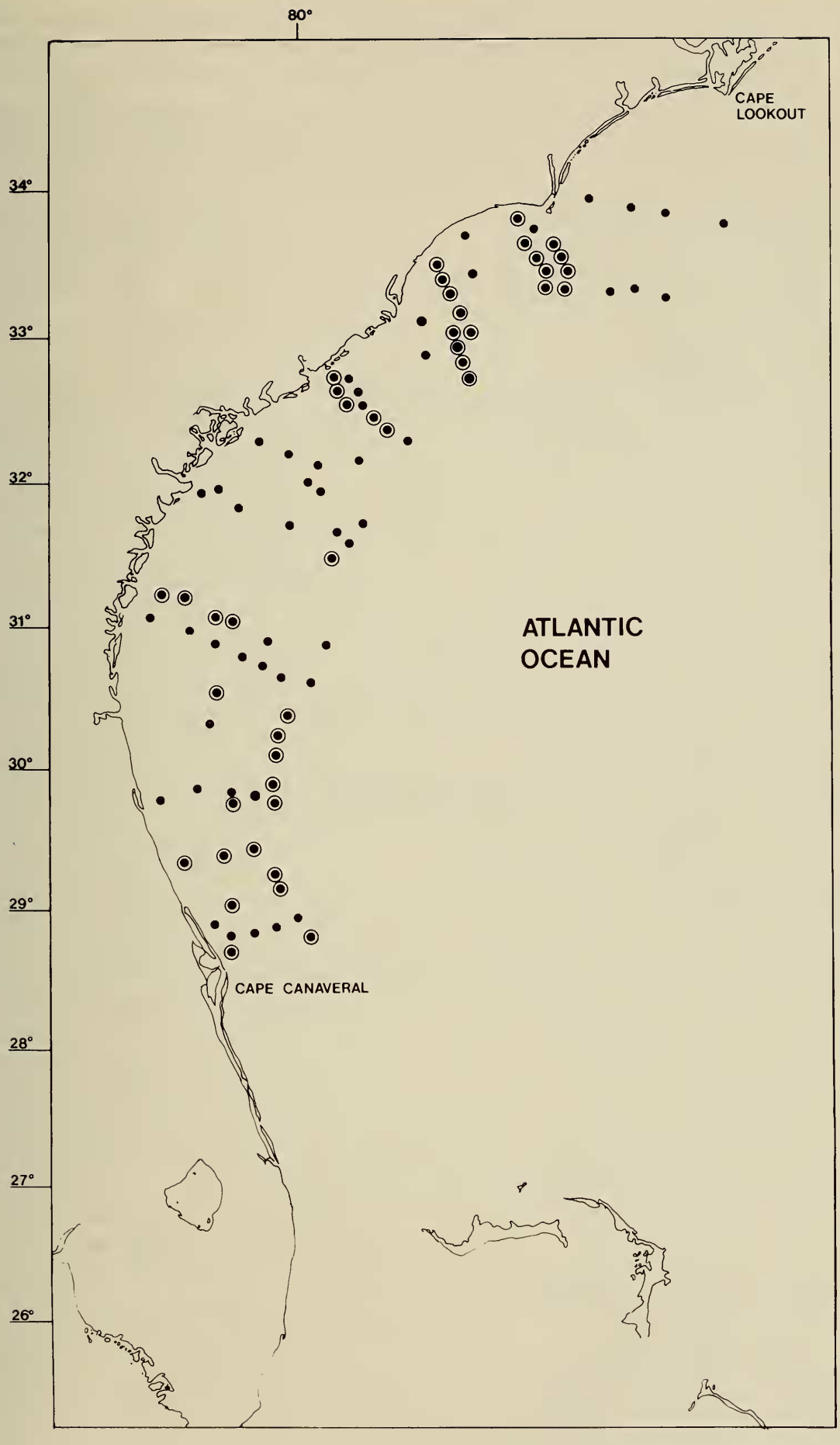

Fig. 1. Station locations for water samples along the southeastern continental shelf taken October–November 1973 (◉) and September 1978 (●).

Table 2.—Phytoplankton composition and average cell concentrations (no's/l) for combined stations in the 1973 and 1978 cruises. Counts for the filamentous cyanophyceans are in filaments per liter.

	Stations	
	Near shore	Far shore
BACILLARIOPHYCEAE		
Achnanthes longipes Agardh	—	0.09
Actinoptychus senarius Ehrenberg	0.29	0.09
Actinoptychus vulgaris Schumann	0.57	0.09
Amphiprora sp.	0.19	—
Amphiprora alata (Ehrenberg) Kutzing	—	0.09
Amphora sp.	0.38	—
Amphora binodis Gregory	7.90	0.87
Amphora cuneata Cleve	8.38	—
Amphora egregia var. *interrupta* Peragallo & Peragallo	—	0.04
Amphora grevilleana contracta Cleve	—	0.17
Amphora marina (W. Smith) Van Heurck	0.38	1.04
Amphora obtusa Gregory	0.19	0.09
Amphora ostrearia Brebisson	4.00	0.52
Amphora ovalis Kutzing	0.95	0.70
Amphora peragalli Cleve	—	0.17
Amphora terroris Ehrenberg	4.57	—
Asterionella glacialis Castracane	3.05	2.09
Asterionella kariana Grunow	—	4.00
Asteromphalus flabellatus (Brebisson) Greville	2.10	0.43
Auliscus sculptus (W. Smith) Ralfs	—	0.09
Bacteriastrum comosum Pavillard	—	1.13
Bacteriastrum delicatulum Cleve	4.38	9.74
Bacteriastrum hyalinum Lauder	3.62	12.91
Bacteriastrum hyalinum var. *princeps* (Castracane) Ikari	—	0.17
Bacteriastrum varians Lauder	—	0.96
Biddulphia alternans (Bailey) Van Heurck	97.05	0.57
Biddulphia aurita (Lyngbye) Brebisson	4.67	0.17
Biddulphia longicruris Greville	0.57	0.52
Biddulphia mobiliensis (Bailey) Grunow	2.95	0.52
Biddulphia sinensis Greville	0.10	0.04
Biddulphia tridens (Ehrenberg) Ehrenberg	0.76	—
Campylodiscus limbatus Brebisson	—	0.09
Campylodiscus rutilis Skvortzow	—	0.04
Chaetoceros affine Lauder	17.32	1.0
Chaetoceros atlanticum Cleve	6.48	6.26
Chaetoceros breve Schutt	29.52	28.48
Chaetoceros coarctatum Lauder	10.86	3.45
Chaetoceros compressum Lauder	—	0.70
Chaetoceros convolutum Castracane	—	0.52
Chaetoceros curvisetum Cleve	—	0.35
Chaetoceros decipiens Cleve	63.24	25.87
Chaetoceros densum Cleve	0.38	1.13
Chaetoceros didymum Ehrenberg	—	0.09
Chaetoceros diversum Cleve	22.29	3.48
Chaetoceros gracile Schutt	—	0.35
Chaetoceros laciniosum Schutt	—	0.26
Chaetoceros lorenzianum Grunow	22.86	12.17
Chaetoceros messanense Castracane	0.57	—
Chaetoceros pelagicum Cleve	11.43	—
Chaetoceros pendulum Karsten	—	1.04

Table 2.—Continued.

	Stations	
	Near shore	Far shore
Chaetoceros peruvianum Brightwell	6.10	6.39
Chaetoceros pseudocurvisetum Mangin	2.86	—
Chaetoceros radians Schutt	—	0.43
Chaetoceros sociale Lauder	—	1.65
Chaetoceros wighami Brightwell	—	0.35
Climacodium frauenfeldianum Grunow	35.29	23.91
Cocconeis sp.	5.71	—
Cocconeis molesta var. *crucifera* Grunow	1.14	—
Cocconeis pinnata Gregory	9.14	1.22
Corethron criophilum Castracane	0.38	0.96
Coscinodiscus argus Ehrenberg	0.38	—
Coscinodiscus asteromphalus Ehrenberg	0.76	0.09
Coscinodiscus centralis Ehrenberg	5.81	0.61
Coscinodiscus gigas Ehrenberg	0.38	—
Coscinodiscus grani Gough	9.14	1.13
Coscinodiscus granulosus Grunow	4.95	2.74
Coscinodiscus lineatus Ehrenberg	29.05	3.61
Coscinodiscus marginatus Ehrenberg	28.95	0.61
Coscinodiscus nitidus Gregory	64.00	9.00
Coscinodiscus nobilis Grunow	—	0.09
Coscinodiscus perforatus Ehrenberg	0.38	—
Coscinodiscus radiatus Ehrenberg	—	0.09
Coscinodiscus stellaris var. *symbolophora* (Grunow) Jorgensen	0.38	—
Coscinodiscus wailesii Gran and Angst	0.38	—
Cyclotella sp.	—	6.35
Cyclotella meneghiniana Kutzing	—	0.13
Cylindrotheca closterium (Ehrenberg) Reiman and Lewin	63.05	21.36
Cymatosira belgica Grunow	151.05	33.83
Cymatosira lorenziana Grunow	18.29	1.13
Dactyliosolen antarcticus Castracane	—	0.87
Dactyliosolen mediterraneus Peragallo	—	3.39
Diploneis crabro Ehrenberg	29.52	7.48
Diploneis crabro var. *pandura* (Brebisson) Cleve	11.24	0.35
Ditylum brightwellii (West) Grunow	14.76	0.65
Eucampia zoodiacus Ehrenberg	—	0.09
Eunotia sp.	0.10	—
Eunotia bidentula W. Smith	—	0.09
Fragilaria sp.	—	0.52
Fragilaria crotonensis Kitton	—	0.09
Fragilariopsis cylindrus (Grunow) Helmcke and Krieger	334.29	13.30
Grammatophora sp.	37.52	18.04
Grammatophora angulosa Ehrenberg	0.76	5.30
Grammatophora marina (Lyngbye) Kutzing	—	0.43
Guinardia flaccida (Castracane) Peragallo	50.48	41.91
Gyrosigma sp.	—	0.09
Gyrosigma balticum (Ehrenberg) Cleve	0.38	—
Hantzschia marina (Donkin) Grunow	0.19	—
Hemiaulus hauckii Grunow	23.24	34.48
Hemiaulus membranaceus Cleve	49.52	9.83
Hemiaulus sinensis Greville	47.81	26.80

Table 2.—Continued.

	Stations	
	Near shore	Far shore
Leptocylindrus danicus Cleve	19.24	29.17
Licmophora sp.	0.19	0.39
Licmophora flabellata (Carmichael) Agardh	3.81	0.09
Mastogloia smithii Thwaites	10.29	0.48
Melosira distans (Ehrenberg) Kutzing	49.81	29.57
Melosira granulata (Ehrenberg) Ralfs	17.33	12.09
Melosira granulata var. *angustissima* Muller	22.14	85.74
Melosira islandica Muller	—	4.75
Melosira moniliformis (Muller) Agardh	—	0.04
Melosira nummuloides (Dillwyn) Agardh	—	1.57
Navicula sp.	0.38	0.13
Navicula abrupta (Gregory) Cleve	—	0.26
Navicula annulata Grunow	55.05	6.83
Navicula cancellata Donkin	16.57	1.74
Navicula clavata Gregory	16.19	1.65
Navicula forcipata Greville	25.33	0.52
Navicula lyra Ehrenberg	15.71	0.70
Navicula opima (Grunow) Cleve	0.38	6.35
Navicula praetexta Ehrenberg	0.09	—
Navicula pusilla W. Smith	—	0.17
Nitzschia sp.	—	0.35
Nitzschia angularis W. Smith	4.19	0.43
Nitzschia distans Gregory	9.52	0.61
Nitzschia insignis Gregory	1.52	—
Nitzschia longissima (Brebisson) Ralfs	16.19	8.00
Nitzschia lorenziana var. *densistriata* (Peragallo and Peragallo) Hustedt	1.14	1.39
Nitzschia lorenziana var. *incerta* Grunow	0.76	0.78
Nitzschia lorenziana var. *subtilis* Grunow	0.76	—
Nitzschia panduriformis Gregory	0.76	0.43
Nitzschia pungens Grunow	56.19	2.96
Nitzschia seriata Cleve	—	6.78
Nitzschia sigma (Kutzing) W. Smith	0.38	—
Nitzschia sigma var. *intercedens* Grunow	—	0.87
Nitzschia socialis Ralfs	—	0.17
Nitzschia spathulata Brebisson	4.29	—
Paralia sulcata (Ehrenberg) Cleve	531.05	87.09
Pinnularia sp.	—	0.26
Plagiogramma staurophorum (Gregory) Heilberg	448.00	25.57
Plagiogramma vanheurckii Grunow	—	0.70
Planktoniella sol (Wallich) Schutt	—	0.43
Pleurosigma sp.	0.19	0.52
Pleurosigma angulatum (Quekett) W. Smith	5.24	2.09
Pleurosigma elongatum W. Smith	3.05	1.09
Pleurosigma hamuliferum Brun	30.29	4.51
Pleurosigma nicobaricum (Grunow) Grunow	1.71	—
Pleurosigma normanii Ralfs	3.43	—
Pleurosigma obscurum W. Smith	1.52	—
Podosira stelliger (Bailey) Mann	0.19	—
Rhaphoneis amphiceros Ehrenberg	3.43	1.22
Rhaphoneis surirella (Ehrenberg) Grunow	9.14	3.13
Rhizosolenia acuminata (Peragallo) Gran	2.29	0.26

Table 2.—Continued.

	Stations	
	Near shore	Far shore
Rhizosolenia alata Brightwell	713.52	336.46
Rhizosolenia alata f. *gracillima* (Cleve) Grunow	99.62	19.65
Rhizosolenia alata f. *indica* (Peragallo) Gran	1029.62	404.04
Rhizosolenia bergonii Peragallo	1.33	0.52
Rhizosolenia calcar-avis Schultze	37.62	31.65
Rhizosolenia castracanei Peragallo	0.57	2.52
Rhizosolenia delicatula Cleve	0.76	7.26
Rhizosolenia fragilissima Bergon	0.57	3.30
Rhizosolenia hebetata f. *hiemalis* Gran	0.38	0.09
Rhizosolenia hebetata f. *semispina* (Hensen) Gran	—	2.17
Rhizosolenia imbricata Brightwell	53.33	23.28
Rhizosolenia robusta Norman	3.71	5.30
Rhizosolenia setigera Brightwell	84.94	14.61
Rhizosolenia stolterfothii Peragallo	37.81	167.78
Rhizosolenia styliformis Brightwell	25.24	11.96
Rhizosolenia temperei Peragallo	0.10	1.83
Schroederella delicatula (Peragallo) Pavillard	—	0.78
Skeletonema costatum (Greville) Cleve	36.10	0.96
Stephanopyxis palmeriana (Greville) Grunow	3.43	0.43
Stephanopyxis turris (Greville) Ralfs	32.67	8.04
Surirella crumena Brebisson	—	0.09
Surirella pandura var. *contracta* Peragallo and Peragallo	0.19	—
Synedra crystallina (Agardh) Kutzing	1.90	1.04
Synedra fulgens (Greville) W. Smith	70.10	27.48
Synedra gaillonii (Bory) Ehrenberg	0.95	—
Synedra robusta Ralfs	0.38	—
Synedra tabulata (Agardh) Kutzing	—	0.09
Synedra toxoneides Castracane	0.19	0.09
Synedra undulata Bailey	133.52	1.00
Tabellaria fenestrata var. *asterionelloides* Grunow	97.52	25.22
Thalassionema nitzschioides Hustedt	808.67	144.70
Thalassiosira baltica (Grunow) Ostenfeld	—	0.43
Thalassiosira eccentrica (Ehrenberg) Cleve	13.62	2.09
Thalassiosira gravida Cleve	4.38	1.74
Thalassiosira nordenskioeldii Cleve	25.71	1.61
Thalassiosira subtilis (Ostenfeld) Gran	—	0.13
Thalassiothrix delicatula Cupp	—	1.30
Thalassiothrix frauenfeldii Grunow	99.43	19.61
Thalassiothrix mediterranea Pavillard	12.00	6.63
Triceratium favus Ehrenberg	0.10	0.13
Triceratium formosum var. *pentagonalis* (Schmidt) Hustedt	0.19	—
Tropidoneis lepidoptera (Gregory) Cleve	0.19	0.04
Tropidoneis seriata Cleve	0.57	0.35
Unidentified diatoms	201.14	54.43
DINOPHYCEAE		
Amphidinium acutissimum Schiller	0.38	8.78
Amphidinium acutum Lachmann	—	0.04
Amphidinium bipes Herdman	—	0.91
Amphidinium globosum Schroder	—	0.52
Amphidinium klebsii Kofoid and Swezy	—	0.39

Table 2.—Continued.

	Stations	
	Near shore	Far shore
Amphidinium lanceolatum Schroder	—	0.04
Amphidinium schroederi Schiller	—	3.04
Ceratium contortum (Gourret) Cleve	0.19	0.04
Ceratium contortum var. *karsteni* (Pavillard) Sournia	0.19	0.39
Ceratium digitatum Schutt	—	0.04
Ceratium extensum (Gourret) Cleve	0.19	0.48
Ceratium furca (Ehrenberg) Claparede and Lachmann	11.90	3.83
Ceratium fusus (Ehrenberg) DuJardin	7.71	0.93
Ceratium geniculatum (Lemmermann) Cleve	0.38	—
Ceratium horridum (Cleve) Gran	0.76	—
Ceratium kofoidi Jorgensen	—	0.09
Ceratium lineatum (Ehrenberg) Cleve	4.76	3.30
Ceratium longirostrum Gourret	0.19	—
Ceratium macroceros (Ehrenberg) VanHoffen	0.38	—
Ceratium massiliense (Gourret) Jorgensen	3.33	0.83
Ceratium minutum Jorgensen	—	0.09
Ceratium pentagonum Gourret	0.38	1.83
Ceratium ranipes Cleve	—	0.09
Ceratium setaceum Jorgensen	—	0.17
Ceratium teres Kofoid	—	0.22
Ceratium trichoceros (Ehrenberg) Kofoid	2.48	3.43
Ceratium tripos (Muller) Nitzsch	0.48	0.39
Ceratium tripos var. *atlanticum* (Ostenfeld) Paulsen	0.57	0.78
Dinophysis caudata Kent	11.52	2.22
Glenodinium sp.	—	0.26
Gonyaulax diegensis Kofoid	—	0.43
Gonyaulax fragilis (Schutt) Kofoid	—	0.09
Gonyaulax minuta Kofoid and Michener	0.76	0.09
Gonyaulax monilata Howell	29.14	—
Gymnodinium sp. #1	—	0.70
Gymnodinium sp. #2	—	0.35
Gymnodinium coeruleum Dogiel	—	0.09
Gymnodinium danicans Campbell	0.76	7.87
Gymnodinium variabile Herdman	1.52	0.57
Gyrodinium sp.	1.71	0.09
Gyrodinium dominans Hulburt	—	0.17
Gyrodinium estuariale Hulburt	—	1.22
Gyrodinium fusiforme Kofoid and Swezy	36.57	0.70
Heterocapsa triquetra (Ehrenberg) Stein	—	1.17
Katodinium sp.	—	0.70
Katodinium asymetricum (Massart) Fott	—	0.09
Katodinium rotundatum (Lohmann) Loeblich	15.7	12.85
Oxytoxum gracile Gran	—	0.61
Oxytoxum sceptrum (Stein) Schroder	0.19	—
Oxytoxum variabile Schiller	—	0.22
Peridiniopsis assymetrica Mangin	—	0.09
Podolampas bipes Stein	—	0.61
Podolampas elegans Schutt	0.19	—
Podolampas palmipes Stein	—	0.09
Podolampus curvatus Schiller	—	0.09
Prorocentrum aporum (Schiller) Dodge	17.90	0.52

Table 2.—Continued.

	Stations	
	Near shore	Far shore
Prorocentrum balticum (Lohmann) Loeblich	0.76	0.22
Prorocentrum cassubicum (Woloszynska) Dodge	—	0.09
Prorocentrum compressum (Bailey) Abe	9.43	1.04
Prorocentrum gracile Schutt	—	0.17
Prorocentrum lima (Ehrenberg) Dodge	0.38	—
Prorocentrum maximum (Gourret) Schiller	0.76	—
Prorocentrum micans Ehrenberg	168.48	9.09
Prorocentrum nanum Schiller	6.38	3.83
Protoperidinium sp.	—	0.09
Protoperidinium biconicum (Dangeard) Balech	—	0.04
Protoperidinium breve (Paulsen) Balech	0.19	0.13
Protoperidinium brochii (Kofoid and Swezy) Balech	0.10	0.09
Protoperidinium cerasus (Paulsen) Balech	1.14	0.09
Protoperidinium claudicans (Paulsen) Balech	0.19	0.09
Protoperidinium conicum (Gran) Balech	2.29	0.26
Protoperidinium crassipes Kofoid	—	0.35
Protoperidinium depressum (Bailey) Balech	5.14	0.78
Protoperidinium divergens (Ehrenberg) Balech	0.76	—
Protoperidinium grande (Kofoid) Balech	—	0.04
Protoperidinium leonis (Pavillard) Balech	0.38	—
Protoperidinium oceanicum (VanHoffen) Balech	—	0.35
Protoperidinium pendunculatum (Schutt) Balech	0.57	0.04
Protoperidinium pentagonum (Gran) Balech	0.57	0.09
Protoperidinium quarnerense (Schroder) Balech	—	0.17
Protoperidinium solidicorne (Mangin) Balech	—	0.04
Protoperidinium sphaericum (Okamura) Balech	0.38	0.43
Protoperidinium steinii (Jorgensen) Balech	—	0.96
Unidentified dinoflagellate cysts	0.19	0.70
Unidentified dinoflagellates	62.10	49.87
HAPTOPHYCEAE		
Acanthoica aculeata Kamptner	0.76	0.43
Chrysochromulina sp.	—	0.09
Cyclococcolithus leptoporus (Murray and Blackman) Kamptner	14.29	28.57
Emiliania huxleyi (Lohmann) Hay and Mohler	50.86	60.48
Gephyrocapsa oceanica Kamptner	—	12.96
Hymenomonas carterae (Braarud and Fagerland) Braarud	0.38	0.09
Rhabdosphaera claviger Murray and Blackman	3.05	1.04
Rhabdosphaera hispida Lohmann	3.43	—
Rhabdosphaera stylifer Lohmann	15.62	—
Syracosphaera sp.	0.19	—
Syracosphaera molischii Schiller	—	0.09
Syracosphaera pirus Halldal and Markali	0.76	0.26
Syracosphaera pulchra Lohmann	1.90	2.70
Unidentified coccolithophorids	469.90	127.48
CHRYSOPHYCEAE		
Calycomonas ovalis Wulff	0.09	—
Dictyocha fibula Ehrenberg	50.14	4.00
Distephanus speculum (Ehrenberg) Haekel	0.38	0.35
Ochromonas sp.	158.29	3.22
Ochromonas caroliniana Campbell	0.19	—

Table 2.—Continued.

	Stations	
	Near shore	Far shore
CYANOPHYCEAE		
Agmenellum quadruplicatum (Meneghini) Brebisson	12.38	—
Agmenellum thermale (Kutzing) Drouet and Daily	4.19	—
Anacystis aeruginosa Drouet and Daily	38.48	—
Anacystis dimidiata (Kutzing) Drouet and Daily	87.62	12.43
Anacystis marina (Hansg) Drouet and Daily	543.05	29.83
Entophysalis deusta (Meneghini) Drouet and Daily	2.29	—
Gomphosphaeria aponina Kutzing	45.81	21.43
Johannesbaptistia pellucida (Dickie) Taylor and Drouet	395.85	35.83
Nostoc commune Vaucher	500.95	126.67
Oscillatoria sp.	0.76	—
Oscillatoria erythraea (Ehrenberg) Kutzing	119.90	116.87
Oscillatoria submembranacea Ardissone and Strafforello	17.52	1.74
Richelia intracellularis Schmidt	—	3.13
Schizothrix calcicola (Agardh) Gomont	1.52	—
Schizothrix tenerrima (Domont) Drouet	2.29	—
Spirulina subsalsa Oersted	0.57	—
EUGLENOPHYCEAE		
Euglena sp.	0.19	—
Euglena ehrenbergii Klebs	0.19	—
Euglena fusca (Klebs) Lemmermann	0.19	1.22
Eutreptia lanowii Steuer	1.71	0.35
Eutreptia viridis Perty	0.95	0.17
Trachelomonas sp.	0.10	0.09
Trachelomonas hispida (Perty) Stein	0.38	0.17
CHLOROPHYCEAE		
Chlorella sp.	8.57	1.04
Crucigenia tetrapedia (Kirchner) West and West	1.90	0.87
Staurastrum quadricuspidatum Turner	0.76	—
PRASINOPHYCEAE		
Pyramimonas sp.	0.19	—
Pyramimonas torta Conrad and Kuff	—	0.09
Tetraselmis sp.	0.67	—
Tetraselmis gracilis (Kylin) Butcher	—	0.09
CRYPTOPHYCEAE		
Chroomonas sp.	0.09	—
Cryptomonas sp.	0.38	3.39
Cryptomonas sp. #2	0.09	—
OTHERS		
Unidentified green cells (<3.0 microns)	32,154.76	12,844.57
Unidentified green cells (3–5 microns)	105.95	290.22
Unidentified green cells (5–10 microns)	3.05	2.61

Table 3.—Average concentrations of cells (no's/l) for the various phytoplankton groups at near and far shore stations in 1973 and 1978.

	Near shore		Far shore		
	1973	1978	1973	1978	Combined
Bacillariophyceae	7850	4753	1656	2073	3161
Dinophyceae	621	83	160	53	185
Haptophyceae	949	113	78	126	227
Chrysophyceae	89	<1	10	<1	17
Cyanophyceae	2513	1037	396	299	778
Euglenophyceae	8	1	<1	<1	2
Chlorophyceae	<1	17	<1	2	3
Cryptophyceae	<1	<1	3	3	2
Prasinophyceae	1	<1	<1	<1	<1
Ultraplankton*	4952	56,642	4158	20,435	17,322

* Combined size groups of unidentified cells less than 10 microns in size.

μm group more indiscriminate to a specific taxonomic group. In addition to these non-flagellated forms, there were also some phytoflagellates included in these size categories. An ultraplankton component to estuarine and marine habitats has been recognized in recent years (Malone 1971; McCarthy *et al.* 1974; among others). These cells may include the cyanobacteria (blue-green algae) found widely distributed in the western north Atlantic by Waterbury *et al.* (1979), and Johnson and Sieburth (1979). They are also similar to those found in the Chesapeake Bay plume by Marshall (in press) and off the northeastern U.S. coast by Marshall and Cohn (1981).

The study area represents a broad, crescent-shaped segment of the southeastern continental shelf, that reaches its greatest width in the area between Jacksonville and Savannah. In this region the shelf break is approximately 120 km from the coast. The phytoplankton populations varied over the shelf with distinct groups more characteristic of either the near or far shore stations. Average total concentration of cells was generally greater near shore as was the presence of the taxonomic groups represented in the samples, with the exception of the cryptophyceans, haptophyceans, and an unidentified ultraplankton component (Table 3). During both cruises, the far shore populations of the cryptophyceans, although

Table 4.—Numbers and percentages of species within each group that were noted limited to near and far shore stations, or found at both stations.

	Total	Only at near shore	Only at far shore	In both areas
Bacillariophyceae	194	32 17%	53 27%	109 56%
Dinophyceae	83	12 14%	39 46%	32 40%
Haptophyceae	13	3 23%	4 31%	6 46%
Chrysophyceae	5	2 40%	0	3 60%
Cyanophyceae	16	8 50%	1 6%	7 44%
Euglenophyceae	7	2 29%	0	5 71%
Chlorophyceae	3	1 33%	0	2 67%
Cryptophyceae	3	2 67%	0	1 33%
Prasinophyceae	4	2 50%	2 50%	0

not high, were greater than what was found at near shore stations. However, the total phytoplankton composition was dominated by diatoms, dinoflagellates, haptophyceans, cyanophyceans, and the ultraplankton component during both cruises over the shelf. The total near shore populations included more of the smaller sized diatoms, whereas over the central and far shelf, larger sized diatoms were abundant. Of the 194 diatoms, 56% of the species were found at both near and far shore stations, with another 17% limited to the near shore and 27% noted only at far shore stations (Table 4). The prominent diatoms over the shelf were *Cymatosira belgica, Paralia sulcata, Plagiogramma staurophorum, Rhizosolenia alata, R. alata indica, R. stolterfothii,* and *Thalassionema nitzschioides* (Table 5). *Rhizosolenia alata* averaged 713 and 404 cells/l at near and far shore stations, with *R. alata indica* averaging 1029 and 404 cells/l at near and far shore sites. In 1978, *Rhizosolenia alata indica* reached 18,472 cells/l directly off Savannah, with other "pockets" of high concentration scattered over the shelf. These two species, with *Rhizosolenia alata gracillima, R. calcar avis, R. hebetata semispina, R. setigera, R. stolterfothii,* and *R. styliformis* represented a common diatom and generic assemblage throughout the shelf.

The phytoflagellates were not found in high concentrations in these collections but were generally widely distributed. Only 14% of the dinophyceans (Pyrrhophyceans) were limited to the near shore stations, with 40% of the species found at both near and far shore sites and 46% limited to the far shore stations. The haptophyceans, (Prymnesiophyceans) consisted mostly of coccolithophores, with 46% of this class common across the shelf and 31% of the species limited to the far shore sites. The euglenophyceans, chlorophyceans, and chrysophyceans were found in low concentrations, but widely distributed over the shelf, with cyanophyceans, and prasinophyceans more common near shore. The prominent near shore dinophyceans were *Prorocentrum micans, P. aporum, Gyrodinium fusiforme, Gonyaulax monilta,* with *Ceratium furca, Dinophysis caudata,* and *Katyodinium rotundatum* common over the entire shelf. Other characteristic near shore species include *Emiliania huxleyi, Ochromonas* sp., *Dictyocha fibula, Anacystis marina,* and *Johannesbaptistia pellucida.* A far shore dominant was *Emiliania huxleyi,* with *Cyclococcolithus leptoporus* and *Oscillatoria erythraea* found over the shelf in significant numbers. There was no increase in cell concentrations at stations near the shelf break during either of these cruises. Total phytoplankton populations were generally low, but gave evidence of patchiness in cell concentrations over the entire area during both cruises.

Discussion

The shelf phytoplankton possessed a diverse assemblage of 328 species from ten taxonomic categories. Diatoms, dinophyceans, haptophyceans, cyanophyceans, and the ultraplankton component represented the most abundant forms and were distributed over the entire shelf. Each of these categories had characteristic species in the near and far shore stations, with several species common to both (e.g. *Rhizosolenia alata, R. alata indica, Emiliania huxleyi,* etc.). The cyanophyceans were more concentrated in the near shore areas, with many species widely distributed over the shelf. It is also suggested that many of the ultraplankters (size <3 μm) are cyanophyceans which may indicate added sig-

Table 5.—Prominent phytoplankton associated with near and far shore stations during the 1973 and 1978 collections.

Near shore assemblage	Far shore assemblage
Diatoms	Diatoms
Biddulphia alternans	*Chaetoceros decipiens*
Cymatosira belgica	*Climacodium frauenfeldium*
Chaetoceros decipiens	*Guinardia flaccida*
Fragilariopsis cylindrus	*Rhizosolenia alata*
Cylindrotheca closterium	*Rhizosolenia alata indica*
Guinardia flaccida	*Rhizosolenia stolterfothii*
Hemiaulus sinensis	*Thalassionema nitzschioides*
Melosira distans	*Melosira granulata angustissima*
Paralia sulcata	Dinophyceans
Plagiogramma staurophorum	*Ceratium furca*
Rhizosolenia alata	*Dinophysis caudata*
Rhizosolenia alata gracillima	*Katyodinium rotundatum*
Rhizosolenia alata indica	Others
Rhizosolenia setigera	*Emiliania huxleyi*
Synedra fulgens	*Cyclococcolithus leptoporus*
Synedra undulata	*Oscillatoria erythraea*
Tabellaria fenestrata asterionelloides	*Cryptomonas* sp.
Thalassionema nitzschioides	Ultraplankton component
Thalassiosira frauenfeldii	
Dinophyceans	
Gonyaulax monilta	
Gyrodinium fusiforme	
Prorocentrum micans	
Prorocentrum aporum	
Ceratium furca	
Dinophysis caudata	
Katodinium rotundatum	
Others	
Emiliania huxleyi	
Ochromonas sp.	
Dictyocha fibula	
Anacystis marina	
Johannesbaptistia pellucida	
Ultraplankton component	

nificance in the presence of this group to the region. These cells also appear widely distributed over the eastern shelf of the United States (Marshall and Cohn, 1981). Other representatives within this size category and the 3–5 μm group appear to include chlorophyceans, among other types. Many of these phytoplankters may represent the so called "lesser" systematic categories (rather than the dinophyceans, diatoms, and haptophyceans). Of note are the cryptophyceans, whose concentrations were not high in these collections in comparison to the more prominant groups, but maintained a broad distribution pattern over the shelf. However, the total significance of this and other groups is not completely represented in this study. Although the present collections include an extensive shelf coverage from two different cruises, there was a temporal limitation of the

data (both cruises were in the fall and each covered a limited time span for the collections). Some smaller scale variations in composition and concentrations also occurred along the transects between adjacent stations. This patchiness involved high concentrations of one or more species at scattered locations during both cruises and was more typically found among species of diatoms and dinoflagellates. There was also a pattern of high cell counts for the ultraplankton component at stations nearest the estuaries with decreasing concentrations seaward. However, the contributions of this unidentified ultraplankton component to the biomass of the standing crop appeared to be consistently small in comparison to the amount attributed by diatoms and dinoflagellates. Unknown is the long term impact of these cells to the productivity and annual biomass totals for this area.

Pollen and moth scales were also common in the samples and both were noted at stations up to 100 km off the coast. *Rhaphoneis surinella* was found only attached to grains of sediment that were collected in the water column. *Richelia intracellularis* was not found in a free state but as an endosymbiont in *Rhizosolenia styliformis* and *R. hebetata semispina*. Epibiotic fungi (chytridiaceans) were also noted on *Rhizosolenia alata indica*. The reported dinoflagellate cysts consisted mainly of *Protoperidinium pentagonum*.

In summary, the results from collections at 91 shelf stations indicated higher concentrations for each taxonomic group, except the cryptophyceae, and haptophyceans, near shore during both collection periods. This pattern was also noted for the unidentified ultraplankton component. Exceptions to this pattern were common, and occurred as patchiness of species dominance and major shifts in individual concentration values along transects. The shelf populations were dominated by numerous large sized centric diatoms (e.g. *Rhizosolenia alata* and *R. alata indica*), with clusters and single filaments of the cyanophycean *Oscillatoria erythraea* also common. However, numerous small sized cyanophyceans, diatoms and phytoflagellates were also characteristic of the shelf region. Another prominent group was the cyanophyceans, these were widespread over the shelf, often illustrating patchiness and high concentrations of cells near estuaries. Marshall (1981) associates many of the coastal marshes bordering the inner shelf area as a possible origin for many of these cyanophyte species.

Not observed in this study was the pattern of increased cell concentrations from the middle to outer shelf areas, as noted by Bishop *et al.* (1980). However, a similar increase in cell concentrations near the shelf break was noted by Marshall (in press) off the Virginia coast. In contrast, the results at shelf stations from these cruises were generally uniform in their composition and concentrations, with occasional patchiness found broadly distributed, but more centered near and slightly beyond coastal estuaries. However, it is noted that these cruises were both limited to fall collections and covered a brief collection period.

Acknowledgments

Appreciation is given to the National Marine Fisheries Service (MARMAP Program) in cooperation with the South Carolina Marine Resources Institute of Charleston, South Carolina, which provided the samples and supplementary station data, with special thanks to Drs. Victor Burrell and Charles Baran. Further ap-

preciation is given to graduate assistants Charles K. Rutledge, Stephen Cibik, Brad Fawley, and Laurie Kalenak for their contributions in this study, and to Dr. Paul Kirk for identification of the chytridiacean fungi.

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